Indian Journal of Engineering

ANALYSIS

ISSN 2319 – 7757 EISSN 2319 –7765

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Publication History
Received: 29 April 2016
Accepted: 26 May 2016
Published: 1 July 2016

Citation
Waghmare SN, Raut DN, Mahajan SK, Bhamare SS. Improving reliability for SMES in India by using faults classification. *Indian Journal of Engineering*, 2016, 13(33), 354-361

IMPROVING RELIABILITY FOR SMES IN INDIA BY USING FAULTS CLASSIFICATION

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Abstract

In today's dynamic environment, a reliable production system has been anticipated as a critical factor for competitiveness, SMEs in India are facing challenges due to growing competition to sustain themselves. Enhancing their quality and also quality of the products is absolutely essential to sustain growth. Quality of production process means reliable and sustainable process. Therefore it is necessary for SMEs in India to maximise their current resources, process reliability and reduction of wastes in equipment. Failure Mode Effects Analysis (FMEA) is one of the most effective techniques to achieve high reliability. In this paper a classification of faults for SMEs in India is introduced which is an extension of the standard FMEA. A survey was carried out and data collected from different SMEs (473 industries) through questionnaire supplied to them. The Statistical Package for Social Sciences version 16 was used to analyse the effect of independent variables such as equipment problem, procedure problem, personnel error, and design problem, training deficiency, and management problem, external phenomena on dependent variables such as severity, occurrence, and detection. This paper provides guidelines for SMEs in India to improve reliability of manufacturing process without investing the resources.

Keywords: Reliability, FMEA, Faults classification, SMEs in India

1. INTRODUCTION

Micro, small and Medium Enterprises (MSMEs) are one of the most vibrant and sensitive sectors in Indian economy. The significance of Micro, small and Medium Enterprises (MSMEs) is attributable to its capacity of employment generation, low capital and technology requirement, use of traditional or inherited skill, use of local resources, mobilization of resources and exportability of products. Despite their high enthusiasm and inherent capabilities to grow, SMEs in India are also facing a number of problems like technological obsolescence, increasing domestic and global competition, and change in manufacturing strategies. With the introduction of reform measures in India since 1991, the Govt. has withdrawn many protective policies for the Micro, Small and Medium Enterprise (MSMEs) and introduced promotional policies to increase competitiveness of the sector. To survive with such issues and compete with large and global enterprises, SMEs need to adopt innovative approaches in their operations (Annual Report 2012-13 Govt. of India).

Failure modes and effects analysis (FMEA) is one potential tool used in reliability engineering. FMEA is a reliability procedure which documents all possible failures in a

system design within specified ground rules. It determines, by failure mode analysis, the effect of each failure on system operation. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones (George Pantazopoulos*et al.*, 2005). The risk priority number (RPN). This number is used to rank order the various concerns and failure modes associated with a given design or process. *RPN* = Severity (S) x Occurrence (O) x Detection (D).

2. LITERATURE REVIEW

M. Kostina *et al.* (2012) developed a reliability assessment method with an extension of the existing ones and pooling them to a common framework & the system must identify the most unreliable parts of a production process and suggest the most efficient ways for the reliability improvement. FMEA is in the centre of the proposed frame work, a reliability analysis type, and the most widely used in enterprises. The current research suggests extending the FMEA by introducing a classification of faults. T. Karaulova, (2012) used Faults classification for machinery enterprises developed the reliability assessment .The system identified the most unreliable parts of a production process and suggests the most efficient ways for the reliability improvement. JevgeniSahno *et al.* (2013) proposed Faults Classification for a Machinery Enterprise. Reliability engineering is dealing with an analysis of the causes of the faults in factories and developed a faults classification based on DOE-NE-STD-l004-92 standard shown as follows.

(1) Equipment Problem-Defective or failed part, Equipment failures, Bad equipment works, Contaminations, Critical human errors,
(2) Procedure Problem-Defective or inadequate, Lack of procedure, Error in equipment or material selection, Error in tool or cutting data selection.
(3) Personnel error-In adequate work environments, in attention to detail, Violation of requirement or procedure, Verbal communication problems.
(4) Design Problem-Inadequate designs, Drawing specification, or data error, Dimensions related problems, and Technological parameters problems.
(5) Training deficiency-No training provided, insufficient practice or hands-on experience, in adequate content, insufficient refresher training on or materials, inadequate presentations or materials.
(6) Management problem-Inadequate administrative controls, Work organisations or planning deficiency, Inadequate supervisors, Improper resource allocations, Policy not adequately defined or enforced,
(7) External Phenomena-Communication problems, Time delivery error, Defective product or material.

3. RESEARCH METHODOLOGY

Dependent variables are the ones that depend on other variables. The value of dependent variable depends on independent variable. They are not directly tangible, but have a strong

correlation with independent variables. Independent variables mainly contribute to measurement of model Patil*et al.*, (2012). In this Research model, the Independent variables are equipment problem, procedure problem, personnel error training deficiency, management problem, and external phenomena. The dependent variables are severity, occurrence, and detection. Based on the literature review following hypotheses are investigated in the empirical analysis:

3.1 CONCEPTUAL FRAMEWORK

The investigation in the scope of research problem is governed by the conceptual framework presented in Figure 1.

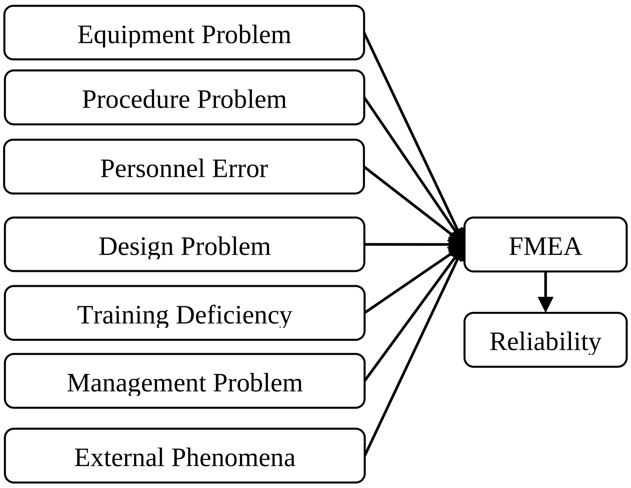

Figure 1. Conceptual Framework

3.2 HYPOTHESIS

H1 Equipment Problem (EP) has significant effect on the production process.
H2 Procedure Problem (PP) has significant effect on the production process.
H3 Personnel Error (PE) has significant effect on the production process.
H4 Design Problem (DP) has significant effect on the production process.
H5 Training Deficiency (TD) has significant effect on the production process.
H6 Management Problem (MP) has significant effect on the production process.
H7 External Phenomena (EXP) has significant effect on the production process.

3.3 DATA COLLECTION

The initial sampling that is list of SMEs in Ratnagiri and Kolhapur is obtained from the district industrial centres. The email ids were collected and the questionaries’ were mailed to 710 respondents out of which 473 responded. The %age of response obtained was 66.61%. As Hair *et al*. (2012) suggests a general rule for researcher to obtain observations five times greater than the number of variables to be analysed. Thus 473 were adequate to take up the analysis. The sample (sample size = 473) of this pilot study focuses on SMEs across Maharashtra India. To conduct the survey the industries away from metro cities are preferred. The survey covers majorly industries from Kolhapur, Ratnagiri and few industries from Pune, Thane & Mumbai, those were included in other. Fig.1 shows the sample coverage.

3.4 MEASURES

Respondent were asked to rate Severity, Occurrence, Detection & Quality important to their industry on production process.

Scale for Severity- 1=None, 2= Slight, 3=Moderate, 4= High Severity, 5= Extreme Severity
Scale for Occurrence - 1=Extremely Unlikely, 2=Very Low Likelihood, 3= Moderately Low Likelihood, 4=Moderately High Likelihood, 5=Extreme Likelihood
Scale for Detection – 1=Extremely Likely, 2=High Likelihood, 3=Medium Likelihood, 4=Low Likelihood, 5=Remote Likelihood

4 VALIDITY AND RELIABILITY

Kaiser-Meyer-Olkin (KMO) & Bartlett's test is used for determining sampling adequacy for conducting factor analysis. First we conducted KMO and Bartlett's test to check sampling adequacy for factor analysis. The KMO values for our test carried out were from 0.653 to 0.909 and Bartlett's value lower than 0.001. The test resulted for KMO in the values greater than 0.5 indicating the sample being adequate for factor analysis (Kaizer, 1974).Bartlett's test of sphericity showed the significance level lower than the 0.001 that the correlation matrix was not identity matrix (Jantunen, A. 2005). Convergent validity is considered to be satisfactory when items load high on their respective factors & all high loadings greater than 0.40 signifying convergent validity Narkhede*et al*., (2012). Reliability is the degree to which measures are free from error and therefore yield consistent results Thanasegaran*et al*., (2009). Internal consistency concerns the reliability of the test components. The most popular method of testing for internal consistency in the behavioural sciences is coefficient alpha Drost*et al.*, (2011). The suggested Cronbach alpha is a minimum of 0.60 Bokade*et al*., (2014), Hair, (2012), Hulland, (1999). The reliability test resulted in Cronbach alpha was 0.613 to 0.865, above 0.60 indicating significant reliability of measures. Table 1 shows correlation matrix & Table 2 shows statistics of construct of occurrence for H1, H2, H3, and H4. Table 3 shows correlation matrix & Table 4 shows statistics of construct of occurrence for H5, H6, and H7. Similarly The KMO values for were from 0.653 to 0.909 , Bartlett's value lower than 0.001 &Cronbach alpha was 0.613 to 0.865 for severity, detection for H1, H2, H3, H4, H5, H6, and H7.

5. RESULTS AND DISCUSSION

We investigated (H1, H2, H3, H4) the effect of Equipment Problem, Procedure Problem, Personnel Error, and Design Problem on severity of failure. The investigation resulted in the R^2 (proportion of variation that is explained by the model) value of 0.921 representing a good model fit. This value is significant to define a high strength of association of the variables (Bokade & Raut 2014). H1 is supported with β value of .385 and P value .000. H2 is supported with β value of .309 and P value .000. H3 is supported with β value of .294 and P value .000. H4 is supported with β value of .269 and P value .000. Again we investigated (H5, H6, H7) the effect of Training Deficiency, Management Problem, and External Phenomena on severity of failure. The resulted in the R^2 value of 0.844 representing a good model fit. H5 is supported with β value of .498 and P value .000. H6 is supported with β value of .407 and P value .000. H7 is supported with β value of .274 and P value .000.
Normality of the error terms were tested by examining Histogram and Normal Probability plot (Bokade&Raut 2014). The simplest diagnostic for normality is a visual check of

histogram and a more reliable approach is the normal probability plot. The normal distribution forms a straight diagonal line and the plotted values are compared with the diagonal. If a distribution is normal the line representing the actual data distribution closely follows the diagonal (Hair *et al*, 2007). Figure 2 shows Histogram for normality check and Figure 3 shows Normal Probability Plot for normality check of H1, H2, and H3, H4 for occurrence& Figure 4 shows Histogram for normality check and Figure 5 shows Normal Probability Plot for normality check of H5, H6, and H7 for occurrence.

Table 1. Correlations matrix

	AVGOCC	EP	PP	PE	DP
AVGOCC	1.000	.785	.725	.720	.683
EP	.785	1.000	.447	.489	.439
PP	.725	.447	1.000	.437	.430
PE	.720	.489	.437	1.000	.381
DP	.683	.439	.430	.381	1.000

Table 2. Statistics of construct

Constructs	KMO values	Cronbach Alpha	Eigen Values	% Variance explained	No. of Factors Indicated
EP	.768	.681	4.165	18.629	05
PP		.698	1.789	26.632	04
PE		.700	1.555	33.587	04
DP		.716	1.434	40.000	04

Table 3. Correlations matrix

	AVGOCC	TD	MP	EXP
AVGOCC	1.000	.837	.869	.774
TD	.837	1.000	.651	.588
MP	.869	.651	1.000	.659
EXP	.774	.588	.659	1.000

Table 4. Statistics of construct

Constructs	KMO values	Cronbach Alpha	Eigen Values	% Variance explained	No. of Factors Indicated
TD		.613	2.739	16.638	05
MP	.653	.630	1.681	26.850	05
EXP		.625	1.557	36.311	03

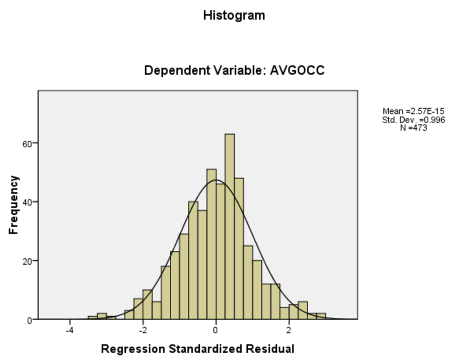

Figure 2. Histogram for normality check

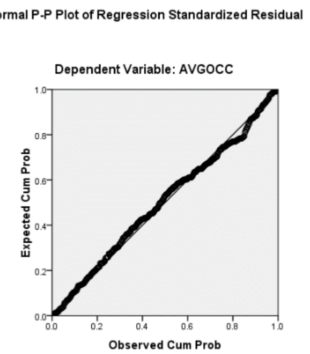

Figure 3. Normal Probability Plot for normality check

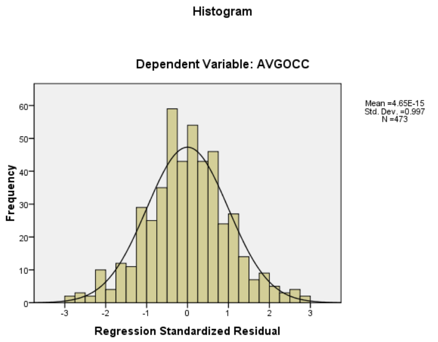

Figure 4. Histogram for normality check

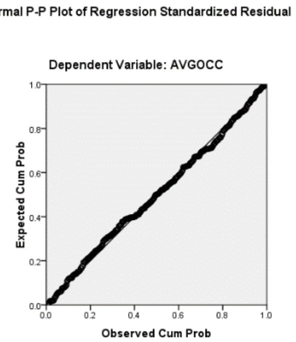

Figure 5. Normal Probability Plot for normality check

The resulting equations after analysis.

For Hypothesis H1, H2, H3, H4

Severity = 0.344 EP + 0.264 PP + 0.241 PE + 0.272 DP................. (1)

Occurrence = 0.385 EP + 0.309 PP + 0.244 PE + 0.269 DP............ (2)

Detection = 0.328 EP + 0.282 PP + 0.300 PE + 0.322 DP .... (3)

For Hypothesis H5, H6, H7

Severity = 0.404 TD + 0.447 MP + 0.242 EXP.............................. (4)

Occurrence = 0.498 TD + 0.407 MP + 0.274 EXP......................... (5)

Detection = 0.432 TD + 0.377 MP + 0.305 EXP............................ (6)

The new equations after multiplication are

Risk Priority Number= 0.0432 EP + 0.0230 PP + 0.0176 PE + 0.0236 DP.............. (9)

Risk Priority Number= 0.0869 TD + 0.0685 MP + 0.0202 EXP............................. (10)

The final equations for Risk Priority Number

For Hypothesis H1, H2, H3, H4, H6, H7,

Risk Priority Number= 0.0432 EP + 0.0230 PP + 0.0176 PE + 0.0236 DP
+0.0869 TD + 0.0685 MP + 0.0202 EXP...................................... (11)

6. CONCLUSION

In this study, we have empirical studied the effect of equipment problem, procedure problem, personnel error training deficiency, management problem, and external phenomena on severity, occurrence and detection of production process.The aim of this paper is to observe effect failures on reliability of SMEs. This paper provides guidelines for SMEs to reduce failures for improving reliability of production process .The study has not considered the cost factor and further research can be carried out by considering cost factor.

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